**MTSE 5560: Compound Semiconductor Materials and Devices**

While silicon dominates the microelectronics sector, its indirect bandgap makes it unsuitable for optical applications.  Technological applications such as diode lasers, LEDs, OLEDs, PLEDs, TFTs, photodiodes etc. all consist of thin-film multi-layers. The epitaxial growth and characterization of compound semiconductor heterojunctions and multilayered thin film structures with a view to satisfying application requirements in the electronic and opto-electronic device areas will be emphasized. A fundamental understanding of the energy band-diagrams for multilayered structures under equilibrium and biasing conditions as well as the influence of material and interface properties on device performance will be stressed.  At the end of this course the participant should able to design complete functional electronic and optoelectronic devices beginning with materials selection based on required electro-optical performance, substrate preparation, material growth, and device design.

**Recommended Texts:** “Physics of Semiconductor Devices”, S.Sze, 2 Edition, Wiley.

“Electronic Thin Film Science for Electrical Engineers and Materials Scientists”, King-Ning Tu, James W. Mayer and Leonard C. Feldman, Macmillan, 1992

Supplementary handouts will be provided.

Two design projects=80% of grade

Homework and quizzes=20% grade

**1. Introduction to compound semiconductors**

i) Schrodinger’s equation for electrons in a periodic potential

ii) Covalent and Ionic bonding

iii) Classes of compound semiconductors

iv) Crystal structures

v) Electronic band structures

vi) Electrical and Optical characterization of semiconductors: Photoluminescence, photoluminescence excitation, absorption, transmission, free carrier concentration and Hall mobility.

**2. Epitaxial growth of compound semiconductor heterostructures**

i) Advantages of epitaxy

ii) Materials issues related to epitaxy

iii) Constraints/limitations of heteroepitaxy

iv Introduction to surface kinetic processes and the Burton-Cabrera-Frank theory of crystal growth

v) Epitaxial growth techniques-MBE and MOCVD, design of high vacuum systems, in-situ diagnostics (AES and RHEED)

vi) Review of post growth characterization for electrical and optical properties

**3. Electronic properties of heterojunctions**

i) Energy band diagrams of ideal single heterojunctions: isotype and anisotype

ii)The influence of interface states: non-ideal heterojunctions

iii) Double heterojunctions

**4. Applications of compound semiconductor heterostructures**

i) Electronic devices:

Review of bipolar transistors

Heterojunction bipolar transistors (HBTs),

Review of MOSFETs

Modulation doped field effect transistors (MODFETs/HEMTs)

ii) Opto-electronic devices:

Review of radiative processes in the solid state

Review of figures of merit for electro-optical devices

LEDS, double heterojunction lasers, photodiodes and photoconductors.

iii) Devices based on metal-insulator-semiconductor structures and interface states

**5. Introduction to organic optoelectronics**

i) Structure and physics of organic light emitting diodes (OLEDs)

ii) Figures of merit for OLEDs